Coronary Artery Bypass Grafting Performed With Or Without A Bypass Pump: Early Results

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Abstract

***Introduction**: Traditionally, heart bypass surgery has required stopping of the heart and the use of cardiopulmonary bypass. Numerous complications have been associated with exposure to this extracorporeal circuit. Newer techniques of local cardiac wall stabilization now enable this operation to be performed safely "Off Pump". The early clinical results of Off Pump Coronary Artery Bypass (OPCAB) will be compared to a similar group of traditional Coronary Artery Bypass Grafting (CABG) patients.*

***Methods**: A retrospective review of 137 consecutive patients undergoing elective coronary artery bypass grafting was performed, 68 of who underwent traditional CABG and 69 of who underwent OPCAB. Inclusion criteria consisted of first time cardiac surgical procedures with an ejection fraction $\geq$ 20%, without significant renal failure (creatinine < 2.0).*

***Results**: There was no statistical difference in the age, sex, cardiac function or underlying co-morbidities between those undergoing CABG and OPCAB. CABG patients had slightly more vessels bypassed than those in the OPCAB group (3.0 vs 2.6, p=0.010). Despite similar preoperative characteristics, the OPCAB group experienced a reduction in morbidity without an increase in mortality.*

***Conclusion**: In similar patient populations, OPCAB was associated with significantly reduced transfusion requirements, intubation time, ICU and overall hospital lengths of stay, with no increase in mortality. Further investigation is warranted to ascertain the role of the OPCAB in the general cardiac surgical community.*

Table1

	OPCAB (n=69)	CABG (n=68)	p- value
Transfusion required	29.0%	45.6%	0.045
Intubation time (hrs)	3.3 ± 7.3	9.5 ± 8.1	< 0.001
ICU LOS (days)	1.5 ± 1.0	2.4 ± 3.1	0.027
Hospital LOS (days)	4.9 ± 2.2	6.6 ± 4.2	0.005
CVA	0 (0%)	2 (3%)	0.150
Death	0 (0%)	2 (3%)	0.150

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Introduction

With our aging population, ischemic coronary disease is becoming an increasingly prominent health care problem. Over 800,000 coronary artery bypass grafting operations (CABG) are performed annually worldwide. Traditionally, CABG is performed with cardiopulmonary bypass (CPB) and global cardiac arrest to create a still and bloodless operative field. CPB however, can be associated with significant morbidity and mortality.

Multiple organ systems are deleteriously affected by the systemic inflammatory response, which ensues following exposure of the body to CPB. Organs involved include the heart, lungs, central nervous system, kidneys and gastrointestinal tract.[1] Cardiac damage has been attributed to activated neutrophils, oxygen free radicals and cytotoxins that cause myocardial edema and decreased contractility. Pulmonary dysfunction has been attributed to the degradation of surfactant, activation of complement and neutrophils, and consequent increased capillary permeability, interstitial edema, atelectasis, and decreased compliance. Neurologic complications such as stroke and neurocognitive dysfunction may be related to cerebral microemboli, associated with CPB, aortic cannulation, or surgical manipulation of the aorta. In one prospective multi-institutional study of 2108 patients undergoing CABG with CPB, stroke was seen in 3% overall.[2] Risk factors for a stroke following CABG with CPB included older age (> 70 years old = 6.1% stroke rate), history of a prior stroke (10.1 % stroke rate), uncontrolled systolic hypertension (11.0% stroke rate), and chronic obstructive pulmonary disease (6.1% stroke rate). In another prospective trial, neurocognitive dysfunction, which is defined as deterioration in intellectual functioning, confusion, agitation, disorientation, or memory deficit, was seen in 73% of patients following CABG with CPB tested at 8 days postop. Follow-up testing showed initial improvement at 2 months (38% had deficit) that seemed to plateau at one year (35% had deficit).[3,4]

Interest in minimizing the trauma of heart surgery has spurred investigation into less invasive approaches. The Off Pump Coronary Artery Bypass (OPCAB) utilizes new techniques of local cardiac wall stabilization, which allow accurate suture placement on the beating heart. All coronary vessels are approachable with this operation and the OPCAB completely avoids the need to place the body on CPB. We will examine the early clinical experience with this new procedure.

Methods

A retrospective review of consecutive patients undergoing elective coronary artery bypass grafting was performed. Inclusion criteria were first time cardiac surgical procedures with ejection fractions ≥ 20%, without significant renal dysfunction (creatinine < 2.0). In order to compare patient populations undergoing a similar number of bypass grafts, all traditional CABG patients who underwent ≤ 3 grafts from January 1998 through May 1999 were included. Patient accrual was from May 1998 through May 1999 (OPCAB), and January 1998 through May 1999 (CABG). These procedures were performed at the St. Francis Medical Center at Liliha, Queens Medical Center, and Kuakini Medical Centers, all located in Honolulu, Hawaii. Informed clinical consent was obtained in all cases. Statistical analysis was performed using SPSS statistical software. Paired t tests were utilized. Differences at the 95% confidence level were considered to be statistically significant.

Results

69 OPCAB and 68 CABG patients were compared. There was no statistical difference in the age (OPCAB 64.8 years, CABG 66.0 years), sex distribution (OPCAB 73% male, CABG 76% male), estimated ejection fraction (OPCAB 55.5% vs CABG 50.9%) or underlying co-morbidities between those undergoing OPCAB and CABG. CABG patients had slightly more vessels bypassed than those in the OPCAB group (3.0 vs 2.6 $p = 0.01$). In this series, 10/68 (14.7%) CABG patients had more than 3 coronary vessels bypassed (4.4 ± .7 bypass grafts) whereas 11/69 (15.9%) in the OPCAB group had more than 3 bypasses performed (4.0 ± 0 bypass grafts). Despite these similar preoperative characteristics, the OPCAB group experienced reduced morbidity compared to those undergoing traditional CABG, with no increase in mortality. Intensive care unit and overall hospital lengths of stay were also reduced. (Table 1)

Discussion

Our early experience with the OPCAB has been encouraging. We have been subjectively impressed with the reduced trauma this operation seems to be associated with in selected patients. This study verifies our impression of a more favorable early clinical result with the OPCAB. The reductions in transfusion requirements, intubation time, ICU and overall hospital lengths of stay are tangible benefits both to the patient directly and to society in general, in terms of reduced medical expenditure and preservation of resources.

Of those patients undergoing traditional CABG, 45.6 % required postoperative blood and blood product transfusions. This compares favorably with the reported 75% transfusion rate in a group of 100 patients undergoing CABG with CPB at a major metropolitan medical center.[5] Unfortunately, this rate of blood and blood product transfusions are not uncommon after coronary bypass surgery and is attributed largely to the damaging effects of CPB on platelet function, and the coagulation cascade. The necessity for high dose heparinization as well as the hypothermia associated with traditional CABG with CPB, are contributing factors as well. In contrast, those patients undergoing the OPCAB are never subjected to the rigors of cardiopulmonary bypass. Platelets and clotting function are preserved. A lower dose of heparin is utilized and the patients are kept warm throughout the procedure. Accordingly, the reduction in transfusion requirements with the OPCAB procedure (29.0%) should not be surprising.

The damaging pulmonary effects of CPB can be profound. Pulmonary interstitial edema is common after CPB and requires vigorous diuresis and prolonged ventilation. Atelectasis and reduction in surfactant levels have been associated with CPB and the lack of ventilation of the lungs during a traditional CABG procedure. In contrast, the OPCAB patients are ventilated thoughout the entire procedure and are ready for extubation in many cases almost immediately. In this series, over 50% of the OPCAB patients were successfully extubated on the operating room table, at the end of the procedure.

A significant reduction in ICU and overall hospital lengths of stay was observed with the OPCAB. The earlier extubation in these patients, no doubt, speeds time to recovery and allows earlier ambulation and resumption of normal nutrition. The reduced pulmonary interstitial fluid allows these patients to wean off of oxygen more quickly, which can lead to a quicker recovery and discharge.

Neurologic sequelae of CABG with CPB can be one of the most feared complications of this procedure. Stroke can have devastating effects for the patient, family and society. It is associated with high in-hospital mortality rates (21% with stroke vs 2% without stroke), longer hospital stays (25 days with stroke vs 10 days without stroke), and higher rates of discharge to intermediate care or nursing home facilities (47% with stroke vs 8% without stroke).[2] Neurocognitive dysfunction is a more subtle neurologic deficit commonly seen after CABG with CPB. Development of these neurologic complications have been associated with cerebral microemboli, generated from a diseased atherosclerotic aorta, from the CPB pump circuit, or through surgical manipulation of the heart and aorta. These microemboli can be detected with use of Transcranial Doppler ultrasound probes placed over the bilateral middle cerebral arteries.[6] Since OPCAB avoids CPB entirely; cerebral microemboli may be reduced with reduced neurologic complications. Interestingly, in this series no strokes were observed in the OPCAB group whereas 2 documented clinical strokes (3%) were seen in the traditional CABG group, resulting in one of the two mortalities in this series. While not reaching statistical significance ($p=0.150$), this trend is supportive of a possible reduction in neurologic complications with the OPCAB.

Clearly there are significant limitations to this study. While consecutive, it is retrospective and subject to significant surgeon selection bias (i.e. perhaps only healthier patients may have had an OPCAB). We hoped to minimize this by using uniform inclusion criteria (elective patients, first time cardiac surgery, ejection fraction ≥ 20 %, no significant renal dysfunction with creatinine < 2.0). We tried to analyze patients with similar numbers of grafts as well. We were fairly successful in our efforts. No significant differences in age, sex or ejection fraction existed between the two groups. Slightly more grafts were performed in the traditional CABG group than in the OPCAB group (3.0 vs 2.6, $p=0.01$), however, a greater percentage of OPCAB patients (15.9%) had greater than 3 grafts performed compared to the traditional CABG group (14.7%).

Graft patency is an obvious important endpoint not addressed in this study. Surgeon selection bias (i.e. perhaps only patients with relatively larger target coronary vessels underwent OPCAB) also limits useful analysis. We believe that only a properly performed prospective randomized trial can adequately answer this question. Early angiographic results by others however, have been reported. Jansen et al[7] in a favorable clinical report of their first 100 patients who underwent multivessel OPCAB documented an angiographic patency rate of 95%. Calafiore and colleagues in 190 consecutive patients and Subramanian in 52 consecutive patients have reported angiographic patency rates of 98.9%,[8] and 96.2%,[9] respectively.

Not all patients can undergo OPCAB. Anatomic and hemodynamic considerations play a role as well as the experience of the surgical team. In this series, 4 patients (5.5%) initially undergoing OPCAB were converted intraoperatively to a traditional CABG. In these patients, hemodynamic instability resulted from either lifting or stabilizing the heart, necessitating conversion. There were no myocardial infarctions or other significant complications in these patients. All were discharged home safely with total hospitalizations ranging from five to nine days (mean 6.5 days). In this study, these patients were included in the traditional CABG group for analysis.

Because of these limitations, definitive conclusions regarding the role of the OPCAB in the general cardiac surgical population cannot be made. Surgeon selection bias can only be overcome with a prospective randomized clinical trial. We believe, however that these results are interesting and warrant further study. Accordingly, we have now embarked and are actively enrolling patients into a prospective randomized clinical trial comparing the OPCAB to traditional CABG. Funded by a grant from the Hawaii Community Foundation, we are studying the effects of the two procedures on neurologic function, morbidity and cost. Pre and postoperative neurologic and neurocognitive function, brain perfusion and intraoperative Transcranial Doppler analysis of cerebral microemboli, are important facets of this ongoing clinical trial.

We believe that the OPCAB is an exciting new procedure, which may have much potential. As with any new medical procedure however, careful and objective study in the context of a prospective randomized protocol should be encouraged.

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